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For	:	ADJUVANT-CONTAINING DNA VACCINES
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ENGLISH TRANSLATION OF PRIORITY APPLICATION

Commissioner for Patents
P.O. Box 1450
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Dear Sir:

Further to the Amendment With Requests For Extension of Time And Interview filed by Express Mail May 12, 2003, submitted herewith is a verified English translation of priority French Application FR9804409, filed April 3, 1998. Please accord the application its April 3, 1998 priority filing date and reconsider and withdraw the rejection based on Ross.

Respectfully submitted,
FROMMER LAWRENCE & HAUG LLP
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Application of : Audonnet et al.)
)
)
Serial No. 09/677,672)
)
Filed : 22/03/1999)
For : Adjuvant-containing DNA vaccines)

VERIFICATION OF TRANSLATION

Hon. Commissioner of Patents
and Trademarks

Sir :

I, the below signator, hereby declare
That my name and post office address are as stated below, and
That I am knowledgeable in the English and French languages, that I believe the attached English document is a true and complete translation of the French Patent Application FR 98 04409, which I have been informed and believe is the application whose priority is claimed in the United States Patent Application Serial No. 09/677,672.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true ; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date : May 15, 2003 Signature

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The present invention relates to an improvement to DNA vaccines, also called plasmid or polynucleotide vaccines, comprising and expressing in vivo one or more heterologous genes. It relates in particular to such improved vaccines, to the use of particular adjuvant compounds for using such vaccines as well as to the vaccination methods relating thereto. Its subject is also a method of preparing these vaccines.

Patent applications WO-A-90 11092, WO-A-93 19183, WO-A-94 21797, WO-A-95 11307 and WO-A-95 20660 have made use of the recently developed technique of polynucleotide vaccines. It is known that these vaccines use a plasmid capable of expressing, in the cells of the host, a gene inserted into the plasmid and encoding an immunogen. All routes of administration have been proposed (intraperitoneal, intravenous, intramuscular, transcutaneous, intradermal, mucosal, and the like). Various means of vaccination may also be used, such as DNA deposited at the surface of gold particles and discharged so as to penetrate into the cells of the skin of the animal (Tang et al., Nature 356, 152-154, 1992) and liquid jet injectors make it possible to transfect into the skin, muscle, fatty tissues and mammary tissues (Furth et al., Analytical Biochemistry, 205, 365-368, 1992).

These polynucleotide vaccines may be used in the form of naked DNA or in the form of a complex with liposomes or cationic lipids.

The objective of the invention is to enhance the efficacy of DNA vaccines by providing new vaccine formulations which are simple and easy to prepare.

Its objective is also to provide such a solution which does not cause strong interactions between the DNA and the other ingredient, which are capable of leading to the formation of a complex.

Its objective is also to provide such a solution which makes it possible, either by simple mixing, to prepare stable vaccines, formulated in a

liquid form, or to easily prepare a liquid vaccine by mixing immediately before use.

The applicant has found, surprisingly, that the carbomer class of compounds meet these various objectives and in particular are capable of acting as adjuvants for naked DNA vaccines in a simple manner but in very advantageous proportions.

The subject of the present invention is therefore a DNA vaccine comprising a naked DNA, in particular circular vaccinal plasmid, supercoiled or not, or a linear DNA molecule, incorporating and expressing in vivo a nucleotide sequence encoding an antigenic polypeptide, preferably a gene of a pathogenic agent, and at least one adjuvant compound chosen from the polymers of acrylic or methacrylic acid and the copolymers of maleic anhydride and alkenyl derivative.

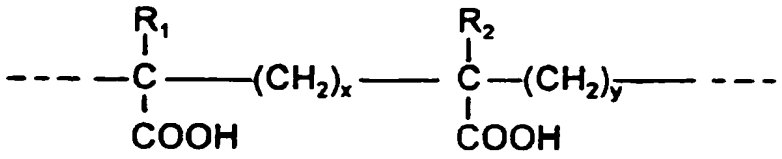
Naked DNA is understood to mean, as is nowadays commonly accepted, a DNA transcription unit in the form of a polynucleotide sequence comprising at least one nucleotide sequence encoding an antigenic polypeptide or an antigen of one valency and the elements necessary for its expression in vivo. The circular plasmid form, supercoiled or not, is preferred. Valency in the present invention is understood to mean at least one antigen providing protection against a pathogen, it being possible for the valency to contain, as sub-valency, one or more natural or modified genes, of one or more strains of the pathogen considered.

The preferred adjuvant compounds are the polymers of acrylic or methacrylic acid which are cross-linked, especially with polyalkenyl ethers of sugars or polyalcohols. These compounds are known by the term carbomer (Pharmeuropa Vol. 8, No. 2, June 1996). Persons skilled in the art can also refer to US-A-2 909 462 which describes such acrylic polymers cross-linked with a polyhydroxylated compound having at least 3 hydroxyl groups, preferably not more than 8, the hydrogen atoms of at least three hydroxyls being

replaced by unsaturated aliphatic radicals having at least 2 carbon atoms. The preferred radicals are those containing from 2 to 4 carbon atoms, e.g. vinyls, allyls and other ethylenically unsaturated groups. The unsaturated radicals may themselves contain other substituents, such as methyl. The products sold under the name Carbopol® (BF Goodrich, Ohio, USA) are particularly appropriate. They are cross-linked with an allyl sucrose or with allyl pentaerythritol. Among them, there may be mentioned Carbopol® 974P, 934P and 971P.

Among the copolymers of maleic anhydride and alkenyl derivative, the EMA® (Monsanto) which are copolymers of maleic anhydride and ethylene, linear or cross-linked, for example cross-linked with divinyl ether, are preferred. Reference may be made to J. Fields et al., Nature, 186: 778-780, 4 June 1960.

From the point of view of their structure, the polymers of acrylic or methacrylic acid and the EMA® are preferably formed of basic units of the following formula:



in which:

- R_1 and R_2, which are identical or different, represent H or CH_3
- x = 0 or 1, preferably x = 1
- y = 1 or 2, with x + y = 2

For the EMA®, x = 0 and y = 2. For the carbomers, x = y = 1.

The dissolution of these polymers in water leads to an acid solution which will be neutralized, preferably to physiological pH, in order to give the adjuvant solution into which the vaccine itself will be incorporated. The carboxyl groups of the polymer are then partly in COO^- form.

Preferably, a solution of adjuvant according to the invention, especially of carbomer, is prepared in distilled water, preferably in the presence of sodium chloride, the solution obtained being at acidic pH. This stock solution is diluted by adding it to the desired quantity (for obtaining the desired final concentration), or a substantial part thereof, of water charged with NaCl, preferably physiological saline (NaCl 9 g/l) all at once or in several portions with concomitant or subsequent neutralization (pH 7.3 to 7.4), preferably with NaOH. This solution at physiological pH will be used as it is for mixing with the vaccine, which may be especially stored in freeze-dried, liquid or frozen form.

The polymer concentration in the final vaccine composition will be 0.01% to 2% w/v, more particularly 0.06 to 1% w/v, preferably 0.1 to 0.6% w/v.

For the vaccination of pigs, the invention may apply in particular to vaccination against Aujeszky's disease virus (PRV or pseudorabies virus), porcine influenza virus (SIV), porcine reproductive and respiratory syndrome virus (PRRS virus), porcine parvovirosis virus (PPV virus), hog cholera virus (HCV virus) and bacterium responsible for actinobacillosis (A. pleuropneumoniae). The plasmids which can be used in the invention comprise, for each valency, one or more of the genes encoding major immunogens of the pathogenic agents considered. There may be mentioned in particular the gB and gD genes for the Aujeszky's disease virus, the HA, NP and N genes for the porcine influenza virus, the ORF5 (E), ORF3 and ORF6 (M) genes for the PRRS virus, VP2 for the parvovirosis virus, E2, E1 + E2, E1 + E2 + C for the hog cholera virus and apxI, apxII and apxIII for A. pleuropneumoniae. In a particularly advantageous manner, reference may be made to the polynucleotide vaccine formulas described in patent application WO-A-98 03 658 (FR-A-2,751,224) which 7relates to vaccines against pig reproductive and respiratory pathologies. This application describes in

particular a number of plasmids which may be directly used by way of examples in the context of the present invention in combination with an adjuvant according to the invention. Persons skilled in the art will thus be able to combine, with the adjuvants in accordance with the invention, the plasmids specifically described in this previous application, namely pAB090 comprising the gB gene of the PRV virus, pPB098 comprising the gD gene of the PRV virus, pPB143 comprising the HA gene of porcine influenza, strain H1N1, pPB142 comprising the NP gene of porcine influenza, strain H1N1, pPB144 comprising the HA gene of porcine influenza, strain H3N2, pPB132 comprising the NP gene of porcine influenza, strain H3N2, pAB025 comprising ORF5 of the PRRS virus, strain Lelystad, pAB001 comprising ORF5 of the PRRS virus, strain USA, pAB091 comprising ORF3 of the PRRS virus, strain Lelystad, pAB092 comprising ORF3 of the PRRS virus, strain USA, pAB004 comprising the VP2 gene of the porcine parvovirus, pAB069 comprising the E1 gene of the hog cholera virus (HCV), pAB061 comprising the E2 gene of the hog cholera virus (HCV), pAB162 comprising the deleted apxI gene of A. pleuropneumoniae, pPB163 comprising the deleted apxII gene of A. pleuropneumoniae, pPB174', pPB189 and pPB190 comprising the deleted apxIII gene of A. pleuropneumoniae.

For the vaccination of horses, there may be mentioned in particular vaccination against equine rhinopneumonia virus (EHV), especially type 1 (EHV-1) and type 4 (EHV-4), against the equine influenza virus EIV, against tetanus (Cl.tetani), against the Eastern encephalitis virus (EEV), Western encephalitis virus (WEV) and Venezuelan encephalitis virus (VEV), as well as against Lyme disease (B. burgdorferi), against equine arteritis (EAV) and against rabies. Among the genes encoding major immunogens which can be used according to the invention, there may be mentioned gB and gD genes for the equine rhinopneumonia valency, especially types 1 and 4, the HA, NA and NP genes for

equine influenza, the C subunit, optionally modified by mutation or deletion, for the tetanus valency, the C and E2 genes for encephalites, the OspA, OspB and p100 genes for Lyme disease, the E, M and N genes for equine arteritis and the G gene for rabies. Such polynucleotide vaccine formulas against horse pathologies are described in particular in patent application WO-A-98 03 198 (FR-A-2,751,226). This application describes a number of plasmids which can be directly used in the present invention in combination with an adjuvant in accordance with the invention. Persons skilled in the art will therefore be able to combine, with the adjuvant in accordance with the invention, a plasmid as precisely described in this application, namely pAB042 comprising the gB gene of the EHV-1 virus, pAB031 comprising the gB gene of the EHV-4 virus, pAB013 comprising the gD gene of the EHV-1 virus, pAB032 comprising the gD gene of the EHV-4 virus, pAB043 comprising the HA gene of equine influenza, Prague strain, pAB033 comprising the HA gene of equine influenza, Suffolk strain, pAB099 comprising the HA gene of equine influenza, Fontainebleau strain, pAB085 comprising the NP gene of equine influenza, Prague strain, pAB084 comprising the NP gene of equine influenza, Jillin strain, pAB070 comprising the gene for the C subunit of the tetanus toxin, pAB017 comprising the OspA gene of Borrelia burgdorferi, pAB094 comprising the E2 gene of the Eastern encephalitis virus, pAB093 comprising the C gene of the Eastern encephalitis virus, pAB096 comprising the E2 gene of the Western encephalitis virus, pAB095 comprising the C gene of the Western encephalitis virus, pAB098 comprising the E2 gene of the Venezuelan encephalitis virus, pAB097 comprising the C gene of the Venezuelan encephalitis virus and pAB041 comprising the G gene of the rabies virus.

For vaccination of dogs, the invention may apply in particular to vaccination against Canine Distemper (Carré's disease) virus (CDV), canine

parvovirus (CPV), canine coronavirus (CCV), canine herpesvirus (CHV), Lyme disease and rabies. Among the genes encoding major immunogens which can be used in the context of the present invention, there may be mentioned most particularly the HA, F, M and N genes for the Canine Distemper virus, the VP2 gene for the canine parvovirus, the S and M genes for the canine coronavirus (CCV), the gB and gD genes for the CHV virus, the OspA and OspB and p100 genes for B. burgdorferi (Lyme disease) and the G gene for rabies. Such polynucleotide vaccine formulas are described in particular in patent application WO-A-98 03 199 (FR-A-2,751,227). Persons skilled in the art will therefore be able to refer to the plasmids described in this application, in combination with the adjuvants in accordance with the invention. Most particularly, they will be able to combine, with the adjuvants in accordance with the invention, the specific plasmids described in this application, namely pAB044 comprising the HA gene of CDV, pAB036 comprising the F gene of CDV, pAB024 comprising the VP2 gene of the canine parvovirus, pAB021 comprising the S gene of CCV, pAB022 comprising the M gene of CCV, pAB037 comprising the gB gene of CHV, pAB038 comprising the gD gene of CHV, pAB017 comprising the OspA gene of B. burgdorferi and pAB041 comprising the G gene of the rabies virus.

For vaccination of bovines, the invention may apply in particular to vaccination against the bovine herpesvirus type 1 or 5 (BHV-1 and BHV-5, responsible for the nervous form of the disease), the bovine respiratory syncytial virus (BRSV), the mucosal disease virus or bovine pestivirus (BVD), the bovine parainfluenza virus type 3 (BPI-3). Among the genes encoding the major immunogens allowing vaccination against these viruses, there may be mentioned in particular the gB and gD genes for the bovine herpesvirus, F and G for the bovine respiratory syncytial virus, E2, C + E1 + E2 and E1 + E2 for the

mucosal disease virus, HN and F for the bovine parainfluenza virus type 3. Such vaccine formulas are described in particular in patent application WO-A-98 03 200 (FR-A-2,751,229). Persons skilled in the art will therefore be able to use the plasmids described in this application in combination with the adjuvants in accordance with the invention. In particular, they will be able to combine, with the adjuvants in accordance with the invention, the plasmids specifically described in this application, namely pPB156 comprising the gB gene of BHV-1, pAB087 comprising the gD gene of BHV-1, pAB011 comprising the F gene of BRSV, pAB012 comprising the G gene of BRSV, pAB058 comprising the C gene of BVD, pAB059 comprising the E1 gene of BVD, pAB060 comprising the E2 gene of BVD, pAB071 comprising the HN gene of BPI-3, pAB072 comprising the F gene of BPI-3.

For the vaccination of cats, the invention may apply in particular to vaccination against the feline leukemia virus FeLV, in particular subtypes A and B, the panleukopenia virus (FPV), the infectious peritonitis virus (FIPV), the coryza virus or feline herpesvirus (FHV), the calicivirosis virus (FCV), the feline immunodeficiency virus (FIV) and the rabies virus (rhabdovirus). Among the genes encoding major immunogens allowing vaccination against these pathogens, there may be mentioned in particular the env and gag/pol genes for feline leukemia, VP2 for panleukopaenia, M and modified S for infectious peritonitis, gB and gD for coryza, capsid for calicivirosis, env and gag/pro for feline immunodeficiency and G for rabies. Polynucleotide vaccine formulas are thus described in patent application WO-A-98 03 660 (FR-A-2,751,223). Persons skilled in the art will be able to combine plasmids as described in this application with the adjuvants in accordance with the invention. In particular, they will be able to combine, with the adjuvants in accordance with the invention, the plasmids specifically described in this application, namely pPB179 comprising the env gene of

the FeLV-A virus, pPB180 comprising the env gene of the FeLV-B virus, pPB181 comprising the gag/pol gene of FeLV-A, pAB009 comprising the VP2 gene of FPV, pAB053 comprising the modified S gene of the FIPV virus, pAB052 comprising the M gene of FIPV, pAB056 comprising the N gene of FIPV, pAB028 comprising the gB gene of FHV, pAB029 comprising the gD gene of FHV, pAB010 comprising the C gene of FCV, pAB030 comprising the env gene of FIV, pAB083 comprising the gag/pro gene of FIV and pAB041 comprising the G gene of the rabies virus.

For vaccination of avian species, the invention may apply in particular to vaccination against the Marek's disease virus (MDV), the Newcastle disease virus (NDV), the Gumboro disease virus (IBDV or Infectious Bursal Disease Virus), the infectious bronchitis virus (IBV), the infectious anemia virus (CAV), the infectious laryngotracheitis virus (ILTV), the encephalomyelitis virus (AEV or avian leukosis virus ALV), the pneumovirosis virus or pneumovirus, and the avian influenza virus. Among the genes encoding the major immunogens which can be used in the present invention, there may be mentioned most particularly the gB and gD genes for the Marek's disease virus, HN and F for the Newcastle disease virus, VP2 for the Gumboro disease virus, S, M and N for the infectious bronchitis virus, C + NS1 for the infectious anemia virus, gB and gD for the infectious laryngotracheitis virus, env and gag/pro for the encephalomyelitis virus, F and G for the pneumovirosis virus and HA, N and NP for avian influenza. Such polynucleotide vaccine formulas are described in patent application WO-A-98 03 659 (FR-A-2,751,225). Persons skilled in the art will therefore be able to refer to the plasmids described in this application in order to combine them with the adjuvants in accordance with the invention. Most particularly, persons skilled in the art will be able to combine, with the adjuvants in accordance with the invention, the plasmids described specifically in this application, namely pAB045 comprising the gB gene of

MDV, pAB080 comprising the gD gene of MDV, pAB046 comprising the HN gene of NDV, pAB047 comprising the F gene of NDV, pAB048 comprising the VP2 gene of IBDV, pAB049 comprising the S1 gene of IBV, pAB050 comprising the M gene of IBV, pAB051 comprising the N gene of IBV, pAB054 comprising the VP1 gene of CAV, pAB055 comprising the VP2 gene of CAV, pAB076 comprising the gB gene of ILTV, pAB089 comprising the gD gene of ILTV, pAB086 comprising the env gene of AEV, pAB081 comprising the gag/pro gene of AEV, pAB082 comprising the G gene of the pneumovirus, pAB077 comprising the HA gene of avian influenza, strain H2N2, pAB078 comprising the HA gene of avian influenza, strain H7N7, pAB088 comprising the NP gene of avian influenza, strain H1N1, pAB079 comprising the N gene of avian influenza, strain H7N1.

Each naked, in particular plasmid, DNA comprises a promoter capable of bringing about, in the host cells, the expression of the gene inserted under its control. It will be in general a strong eukaryotic promoter and in particular a cytomegalovirus early promoter CMV-IE, of human or murine origin, or alternatively possibly of another origin such as rat, pig or guinea pig. In a more general manner, the promoter may either be of viral origin, or of cellular origin. As viral promoter other than CMV-IE, there may be mentioned the SV40 virus early or late promoter or the Rous sarcoma virus LTR promoter. It may also be a promoter coming from the virus from which the gene is derived, for example the actual promoter of the gene. As cellular promoter, there may be mentioned the promoter of a cytoskeleton gene, such as for example the desmin promoter (Bolmont et al., Journal of Submicroscopic Cytology and Pathology, 1990, 22, 117-122; and Zhenlin et al., Gene, 1989, 78, 243-254), or alternatively the actin promoter. When several genes are present in the same naked, in particular plasmid, DNA they may be present in the same transcription unit or in two different units.

Of course, a vaccine may combine, for each of the valencies described above, several genes within the same naked, in particular plasmid, DNA and/or several naked, in particular plasmid, DNAs each comprising one or more genes of the same virus.

The subject of the invention is also multivalent recombinant vaccines, that is to say containing one or preferably two or more naked, in particular plasmid, DNAs expressing antigens for two or more diseases, in the form of a mixture in an adjuvant solution in accordance with the invention.

In the ready-for-use vaccine, the naked DNA, in particular the vaccinal plasmid, is present in the quantities normally used and described in the literature.

The subject of the invention is also a method of vaccination consisting of administering by the parenteral, preferably intramuscular, intradermal, route or by the mucosal route a DNA vaccine in accordance with the invention at the rate of one or more administrations.

The subject of the invention is also the use of the adjuvant compounds in accordance with the invention for the production of adjuvant-containing DNA vaccines as described here.

The invention will now be described in greater details with the aid of the embodiments taken by way of nonlimiting examples and referring to the accompanying figures.

List of figures:

Figure No. 1: Sequence of the hemagglutinin (HA) gene of the equine influenza virus strain Newmarket 2/93

Figure No. 2: Sequence of the hemagglutinin (HA) gene of the equine influenza virus strain Kentucky 1/94

Figure No. 3: Sequence of the neuraminidase (NA) gene of the equine influenza virus strain

Newmarket 2/93

Figure No. 4: Sequence of the neuraminidase (NA) gene of the equine influenza virus strain Kentucky 1/94

Figure No. 5: Sequence of the nucleoprotein (NP) gene of the equine influenza virus strain Newmarket 2/93

Figure No. 6: Sequence of the nucleoprotein (NP) gene of the equine influenza virus strain Kentucky 1/94.

Sequence listing:

SEQ ID No. 1: Oligonucleotide CCL007

SEQ ID No. 2: Oligonucleotide CCL018

SEQ ID No. 3: Sequence of the HA gene, EIV Newmarket 2/93 strain

SEQ ID No. 4: Oligonucleotide CCL020

SEQ ID No. 5: Sequence of the HA gene, EIV Kentucky 1/94 strain

SEQ ID No. 6: Oligonucleotide AB260

SEQ ID No. 7: Oligonucleotide AB262

SEQ ID No. 8: Sequence of the NA gene, EIV Newmarket 2/93 strain

SEQ ID No. 9: Sequence of the NA gene, EIV Kentucky 1/94 strain

SEQ ID No. 10: Oligonucleotide CCL019

SEQ ID No. 11: Oligonucleotide CCL021

SEQ ID No. 12: Sequence of the NP gene, EIV Newmarket 2/93 strain

SEQ ID No. 13: Sequence of the NP gene, EIV Kentucky 1/94 strain

Example 1: Adjuvant

The carbomer used in the vaccines in accordance with the present invention is Carbopol® 974P manufactured by the company BF Goodrich (MW about 3 million).

A stock solution containing 1.5% of Carbopol® 974P was first prepared in distilled water containing sodium chloride at 1 g/l.

This stock solution is then used for the manufacture of a solution of Carbopol® in physiological saline at 4 mg/ml. The stock solution is poured into the entire physiological saline (or optionally into most of it) all at once or optionally in several portions with, each time, adjustment of the pH with the aid of NaOH (for example 1 N or more concentrated) to a value of about 7.3 to 7.4.

A ready-for-use solution of Carbopol® is thereby obtained.

Example 2: Culture of the viruses

The viruses are cultured on the appropriate cellular system until a cytopathic effect is obtained. The cellular systems to be used for each virus are well known to the persons skilled in the art. Briefly, cells sensitive to the virus used, cultured in Eagle's minimum essential medium ("MEM" medium) or another appropriate medium, are inoculated with the viral strain studied using a multiplicity of infection of 1. The infected cells are then incubated at 37°C for the time necessary for the appearance of a complete cytopathic effect (on average 36 hours).

Example 3: Extraction of the viral genomic DNAs

After culture, the supernatant and the lysed cells are harvested and the entire viral suspension is centrifuged at 1000 g for 10 minutes at +4°C in order to remove the cellular debris. The viral particles are then harvested by ultracentrifugation at 400,000 g for 1 hour at +4°C. The pellet is taken up in a minimum volume of buffer (10 mM Tris, 1 mM EDTA). This concentrated viral suspension is treated with proteinase K (100 µg/ml final) in the presence of sodium dodecyl sulphate (SDS) (0.5% final) for 2 hours at 37°C. The viral DNA is then extracted with a

phenol/chloroform mixture and then precipitated with 2 volumes of absolute ethanol. After one night at -20°C, the DNA is centrifuged at 10,000 g for 15 minutes at +4°C. The DNA pellet is dried and then taken up in a minimum volume of sterile ultrapure water. It can then be digested with restriction enzymes.

Example 4: Isolation of the viral genomic RNAs

The RNA viruses were purified according to techniques well known to persons skilled in the art. The genomic viral RNA of each virus was then isolated using the "guanidium thiocyanate/phenol-chloroform" extraction technique described by P. Chomczynski and N. Sacchi (Anal. Biochem, 1987. **162**. 156-159).

Example 5: Molecular biology techniques

All the plasmid constructions were carried out using the standard molecular biology techniques described by J. Sambrook *et al.* (*Molecular Cloning: A Laboratory Manual*. 2nd Edition. Cold Spring Harbor Laboratory, Cold Spring Harbor, New York, 1989). All the restriction fragments used for the present invention were isolated using the "Geneclean" kit (BIO101 Inc. La Jolla, CA).

Example 6: RT-PCR technique

Specific oligonucleotides (containing at their 5' ends restriction sites to facilitate the cloning of the amplified fragments) were synthesized so that they completely cover the coding regions of the genes which have to be amplified (see specific examples). The reverse transcription reaction (RT) and polymerase chain reaction (PCR) were carried out according to standard techniques (J. Sambrook *et al. Molecular Cloning: A Laboratory Manual*. 2nd Edition. Cold Spring Harbor Laboratory, Cold Spring Harbor, New York, 1989). Each RT-PCR reaction was performed with a pair of specific amplimers and taking as template the extracted

viral genomic RNA. The amplified complementary DNA was extracted with phenol/chloroform/isoamyl alcohol (25:24:1) before being digested with restriction enzymes.

Example 7: Plasmid pVR1012

The plasmid pVR1012 was obtained from Vical Inc. San Diego, CA, USA. Its construction has been described in J. Hartikka *et al.* (Human Gene Therapy. 1996. 7. 1205-1217).

Example 8: Construction of the plasmid pCCL027 (Newmarket 2/93 EIV HA gene)

An RT-PCR reaction according to the technique described in Example 6 was carried out with the genomic RNA of the equine influenza virus (EIV) (Newmarket 2/93 strain) (Daly *et al.* J. Gen. Virol. 1996. **77**. 661-671), prepared according to the technique described in Example 4, and with the following oligonucleotides:

CCL007 (40 mer)(SEQ ID No.1)

5' TTGTCGACTCAATCATGAAGACAACCATTATTTTGATACT 3'

CCL018 (34 mer) (SEQ ID No. 2)

5' TTGGATCCTTACTCAAATGCAAATGTTGCACCTG 3'

in order to isolate the gene encoding the HA glycoprotein of the equine influenza virus (Newmarket 2/93 strain) (Figure No. 1, SEQ ID No. 3) in the form of a PCR fragment of about 1750 bp. This fragment was purified and then ligated with the vector pCRII (Cat# K2000-01, Invitrogen Corp. Carlsbad, CA) in order to give the plasmid pCCL026. The plasmid pCCL026 was then digested with the restriction enzymes SalI and NotI in order to isolate an SalI-NotI fragment of 1751 bp containing the Newmarket 2/93 EIV HA gene. This fragment was then ligated with the plasmid pVR1012 (see Example 7), previously digested with SalI and NotI, in order to give the plasmid pCCL027 (6642 bp).

Example 9: Construction of the plasmid pPB242 (Kentucky 1/94 EIV HA gene)

An RT-PCR reaction according to the technique described in Example 6 was carried out with the genomic RNA of the equine influenza virus (EIV) (Kentucky 1/94 strain) (Daly *et al.* J. Gen. Virol. 1996. **77**, 661-671), prepared according to the technique described in Example 4, and with the following oligonucleotides:

CCL007 (40 mer) (SEQ ID No. 1)

5' TTGTCGACTCAATCATGAAGACAACCATTATTTTGATACT 3'

CCL020 (34 mer) (SEQ ID No. 4)

5' TTGGATCCTTACTCAAATGCAAATGTTGCATCTG 3'

in order to isolate the gene encoding the HA glycoprotein of the equine influenza virus (Kentucky 1/94 strain) (Figure No. 2, SEQ ID No. 5) in the form of a PCR fragment of about 1750 bp. This fragment was purified and then ligated with the vector pCRII (Cat# K2000-01, InVitrogen Corp. Carlsbad, CA) in order to give the plasmid pCCL028. The plasmid pCCL028 was digested with the restriction enzymes SacI and BamHI in order to isolate an SacI-BamHI fragment of 1153 bp (fragment A) containing the 3' part of the Kentucky 1/94 EIV HA gene. The plasmid pCCL028 was digested with the restriction enzymes SacI and EcoRV in order to isolate a SacI-EcoRV fragment of 621 bp (fragment B) containing the 5' part of the Kentucky 1/94 EIV HA gene. Fragments A and B were then ligated together with the plasmid pVR1012 (see Example 7), previously digested with EcoRV and BamHI, in order to give the plasmid pPB242 (6688 bp).

Example 10: Construction of the plasmid pAB142 (Newmarket 2/93 EIV NA gene)

An RT-PCR reaction according to the technique described in Example 6 was carried out with the genomic RNA of the equine influenza virus (EIV) (Newmarket 2/93 strain) (Daly *et al.* J. Gen. Virol. 1996, **77**, 661-671), prepared according to the technique described in Example 4, with the following oligonucleotides:

AB260 (35 mer)(SEQ ID No. 6)
5' TTTGTCGACATGAAYCCAAATCAAAARATAATAAC 3'
AB262 (32 mer)(SEQ ID No. 7)
5' TTTGGATCCYTACATCTTRTCGATGTCAAAGG 3'
in order to isolate the gene encoding the neuraminidase (NA) glycoprotein of the equine influenza virus (Newmarket 2/93 strain) (Figure No. 3, SEQ ID No. 8) in the form of a PCR fragment of about 1430 bp. This fragment was purified and then digested with the restriction enzymes SalI and BamHI in order to isolate a SalI-BamHI fragment of 1418 bp containing the Newmarket 2/93 EIV NA gene. This fragment was then ligated with the plasmid pVR1012 (see Example 7), previously digested with SalI and BamHI, in order to give the plasmid pAB142 (6287 bp).

Example 11: Construction of the plasmid pPB246 (Kentucky 1/94 EIV NA gene)

An RT-PCR reaction according to the technique described in Example 6 was carried out with the genomic RNA of the equine influenza virus (EIV) (Kentucky 1/94 strain) (Daly *et al.* J. Gen. Virol. 1996, **77**, 661-671), prepared according to the technique described in Example 4, and with the following oligonucleotides: AB260 and AB262 (Example 10) in order to isolate the gene encoding the neuraminidase (NA) glycoprotein of the equine influenza virus (Kentucky 1/94 strain) (Figure No. 4, SEQ ID No. 9) in the form of a PCR fragment of about 1430 bp. This fragment was purified and then digested with the restriction enzymes SalI and BamHI in order to isolate a SalI-BamHI fragment of 1418 bp containing the Kentucky 1/94 EIV NA gene. This fragment was then ligated with the plasmid pVR1012 (see Example 7), previously digested with SalI and BamHI, in order to give the plasmid pAB116 (6287 bp).

Example 12: Construction of the plasmid pPB245 (Newmarket 2/93 EIV NP gene)

An RT-PCR reaction according to the technique described in Example 6 was carried out with the genomic RNA of the equine influenza virus (EIV) (Newmarket 2/93 strain) (Daly *et al.* J. Gen. Virol. 1996, **77**, 661-671), prepared according to the technique described in Example 4, and with the following oligonucleotides:
CCL019 (25 mer)(SEQ ID No. 10)
5' TTGTCGACCATGGCGTCTCAAGGCAC 3'
CCL021 (28 mer)(SEQ ID No. 11)
5' TTTCTAGACTTTAAYTGTCAWACTCYTC 3'
in order to isolate the gene encoding the nucleoprotein (NP) of the equine influenza virus (Newmarket 2/93 strain) (Figure No. 5, SEQ ID No. 12) in the form of a PCR fragment of about 1520 bp. This fragment was purified and then digested with the restriction enzymes SalI and XbaI in order to isolate a SalI-XbaI fragment of 1506 bp containing the Newmarket 2/93 EIV NP gene. This fragment was then ligated with the plasmid pVR1012 (see Example 7), previously digested with SalI and XbalI, in order to give the plasmid pPB245 (6389 bp).

Example 13: Construction of the plasmid pPB246 (Kentucky 1/94 EIV NP gene)

An RT-PCR reaction according to the technique described in Example 6 was carried out with the genomic RNA of the equine influenza virus (EIV) (Kentucky 1/94 strain) (Daly *et al.* J. Gen. Virol. 1996, **77**, 661-671), prepared according to the technique described in Example 4, and with the following oligonucleotides: CCL019 and CCL021 (Example 12) in order to isolate the gene encoding the nucleoprotein (NP) of the equine influenza virus (Kentucky 1/94 strain) (Figure No. 6, SEQ ID No. 13) in the form of a PCR fragment of about 1520 bp. This fragment was purified and then digested with the restriction enzymes SalI and XbaI in order to isolate a SalI-XbaI fragment of 1506 bp containing the Kentucky 1/94 EIV NP gene. This fragment was then

ligated with the plasmid pVR1012 (see Example 7), previously digested with SalI and XbalI, in order to give the plasmid pPB246 (6389 bp).

Example 14: Construction of the plasmid pPB156 (BHV-1 gB gene)

Its construction is described in WO-A-98 03200.

Example 15: Construction of the plasmid pAB087 (BHV-1 gD gene)

Its construction is described in WO-A-98 03200.

Example 16: Construction of the plasmid pAB090 (PRV gB gene)

Its construction is described in WO-A-98 03658.

Example 17: Construction of the plasmid pPB098 (PRV gD gene)

Its construction is described in WO-A-98 03658.

Example 18: Construction of the plasmid pAB044 (CDV HA gene)

Its construction is described in WO-A-98 03199.

Example 19: Construction of the plasmid pAB036 (CDV F gene)

Its construction is described in WO-A-98 03199.

Example 20: Construction of the plasmid pAB041 (G gene of the rabies virus)

Its construction is described in WO-A-98 03199.

Example 21: Application in horses

The vaccine tested is a mixture of 3 plasmids pCCL027 (Example 8), pAB142 (Example 10) and pPB245 (Example 12) containing and expressing, respectively, the HA, NA and NP genes of the EIV virus strain Newmarket 2/93. This mixture is combined or not with the carbomer as according to the present invention.

The vaccination/challenge protocol was the following:

Group	Number of horses	Vaccine	Diluent	Dose
A	5	pCCL027 + pAB142 + pPB245	Saline solution	3 × 400 µg
B	5	pCCL027 + pAB142 + pPB245	Carbopol® 974P	3 × 400 µg
C	6	Commercial vaccine	---	1 commercial dose
D (controls)	5	---	---	---

Ponies (Welsh Mountain ponies) 7 to 8 months old, having no detectable antibodies against the H3N8 and H7N7 viruses, measured by the SRH (Single Radial Haemolysis) test, were used for this study. The ponies were randomly distributed into 4 groups.

The horses were vaccinated on D0 and D35 by the intramuscular route. The commercial vaccine used for group C was administered to the horses in a dose volume of 1 ml.

The ponies in groups A and B each received 2 doses of 5 ml on D0 and D35 by deep intramuscular injection into the neck.

On D56, three weeks after the second vaccination, each pony was infected by exposure to an aerosol obtained from about 1 ml of allantoic liquid containing a total of $10^{7.3}$ EID_{50} of influenza A-equi-2/Sussex/89 virus, using an ULTRA 2000 model spraying device (De Vilbiss, Somerset PA), as described by Mumford *et al.*, Equine Vet. J. 1990, 22, 93-98.

After the challenge, the ponies were monitored in order to observe the clinical signs (establishment of a clinical score) and the temperature. Nasal swabs were prepared daily from day 0 of the challenge up to the 10th day after the challenge in order to measure

the quantity of virus excreted by each challenged horse.

Finally, blood samples were collected throughout the protocol, before and after the challenge (days D0, D7, D14, D35, D49, D56, D63 and D70) in order to measure the kinetic of appearance and the level of SRH and IHA antibodies (haemagglutinating antibodies) for each vaccinated group.

Example 22: Application in pigs

The efficacy of a plasmid vaccine, combined or not with the carbomer, was studied in pigs in a vaccination/challenge model for Aujeszky's disease. The vaccine tested is a mixture of 2 plasmids pAB090 (Example 16) and pPB098 (Example 17) comprising and expressing, respectively, the gB and gD genes of the PRV virus. The mixture was combined or not with the carbomer as according to the present invention. The vaccination/challenge protocol used was the following:

Group	Number of pigs	Vaccine	Diluent	Dose
A	6	pPB098 + pAB090	Saline solution	2 × 200 µg
B	6	pPB098 + pAB090	Carbopol® 974P	2 × 200 µg
C	6	Geskypur	---	1 commercial dose
D (controls)	6	---	---	---

On D0, the pigs in groups A and B were vaccinated with the mixture of the plasmids pPB098 and pAB090 (200 µg of each plasmid), combined or not with the carbomer, by the intramuscular route, in a volume of 2 ml.

The pigs in group C received an injection of the commercial vaccine Geskypur (subunit vaccine,

MERIAL, Lyon, France) by the intramuscular route in a volume of 2 ml.

The pigs in group D were not vaccinated.

On D21, all the pigs were challenged with 2 ml (at the rate of 1 ml per nostril) of a viral suspension of Aujeszky's challenge strain, strain NIA3 (1/5 dilution of a stock solution titrating $10^{8.25}$ $CCID_{50}$/ml).

After the challenge, the pigs were monitored for mortality and the delta G7 criterion (individual weighings on D0 and D7 of the challenge). Nasal swabs are prepared daily from D0 to D14 of the challenge in order to measure the quantity of virus excreted after the challenge.

Finally, blood samples were collected on D0, D7, D14, D21 and D28 of the protocol in order to measure the kinetic and the Aujeszky's disease virus (PRV) seroneutralizing antibody level. The anti-PRV ELISA antibodies of isotypes IgG1 and IgG2 were also measured in the sera collected in the vaccinated and nonvaccinated pigs.

Example 23: Application in bovines

The efficacy of a plasmid vaccine, combined or not with the carbomer, was studied in bovines in a vaccination/challenge model for infectious bovine rhinotracheitis (IBR) or BHV-1. The vaccine tested is a mixture of 2 plasmids pPB156 (Example 14) and pAB087 (Example 15) comprising and expressing, respectively, the gB and gD genes of the BHV-1 virus. The mixture was combined or not with the carbomer as according to the present invention. The vaccination/challenge protocol used was the following:

Group	Number of calves	Vaccine	Diluent	Dose
A	6	pAB087 + pPB156	Saline solution	2 × 300 µg
B	6	pAB087 + pPB156	Carbopol® 974P	2 × 300 µg
C	6	Ibepur	---	1 commercial dose
D (controls)	6	---	---	---

On D0, the calves in groups A and B were vaccinated with the mixture of plasmid pPAB087 and pPB156 (300 µg of each plasmid), combined or not with the carbomer, by the intramuscular route, in a volume of 5 ml.

The calves in group C received an injection of the commercial vaccine Ibepur (subunit vaccine, MERIAL, Lyon, France) by the intramuscular route in a volume of 2 ml.

The calves in group D were not vaccinated.

On D21, groups A, B and C received a second injection of vaccine according to the same modalities as on D0.

On D35, the calves were challenged with 2.5 ml (at the rate of 1.25 ml per nostril) of a viral suspension of the BHV-1 challenge strain, strain B901 (1/5 dilution of a stock solution titrating $10^{8.15}$ $CCID_{50}$/ml).

After the challenge, the calves were monitored for clinical signs (establishment of a clinical score). Nasal swabs were prepared daily from D0 to D14 of the challenge in order to measure the quantity of virus excreted after the challenge. Finally, blood samples were collected on D0, D7, D14, D21, D35 and D49 of the protocol in order to measure the kinetic and the infectious bovine rhinotracheitis virus (BHV-1) seroneutralizing antibody level. The anti-BHV-1 ELISA antibodies of isotypes IgG1 and IgG2 were also measured

in these sera collected from vaccinated and non-vaccinated calves.

Example 24: Application in dogs

The efficacy of a plasmid vaccine, combined or not with the carbomer, was studied in dogs in a vaccination/challenge model for Carré's disease (CDV). The vaccine tested is a mixture of the 2 plasmids pAB044 (Example 18) and pAB036 (Example 19) comprising and expressing, respectively, the HA and F genes of the CDV virus. The vaccination/challenge protocol used was the following:

Group	Number of dogs	Vaccine	Diluent	Dose
A	6	pAB036 + pAB041	Saline solution	2 × 200 µg
B	6	pAB036 + pAB041	Carbopol® 974P	2 × 200 µg
C	6	EURICAN	---	1 commercial dose
D (controls)	6	---	---	---

The dogs in groups A, B and C were vaccinated on D0 and D28 by the intramuscular route. The dogs in groups A and B received, for each vaccination, an injection of plasmid solution containing 400 µg in total (2 × 200 µg) in a volume of 1 ml.

The dogs in group C were vaccinated with the vaccine EURICAN (CHPPI2) which is a vaccine marketed by Mérial, Lyon, France. One commercial dose contains about 10^4 pfu of CDV Onderstepoort vaccinal strain as well as the valencies for vaccination against Rubarth's hepatitis, canine parvovirosis and type 2 parainfluenza virus.

The challenge was performed on D49 by intracerebral administration of 1/10 dilution of the

CDV "Synder-Hill" challenge strain (batch prepared and provided by USDA, USA).

Clinical monitoring was performed daily for 21 days after the challenge in order to note the signs (general state, oculonasal symptoms, digestive symptoms, nervous symptoms, temperature) (notation according to the rules of the European Pharmacopoeia). The challenged dogs were also weighed once per week.

Protection was assessed on the following criteria:

- mean clinical scores for each group
- CDV viraemia level after challenge (measurement of the viral load in the lymphocytes on D56, D61, D66, D70)
- blood count on blood samples collected on D48, D54, D56, D59, D63 and D70 (that is to say days - 1, 5, 7, 10, 14 and 21 after challenge)
- weight variation after challenge.

For all these criteria, the mean levels for each group were also compared with each other and with the mean level for the control group.

Blood samples were collected on days D0, D14, D28, D56 and D70 for titration of the ELISA antibodies and Carré's disease virus seroneutralizing antibodies.

CLAIMS

1. DNA vaccine comprising a naked DNA incorporating and expressing in vivo a nucleotide sequence encoding an antigenic polypeptide, preferably a gene of a pathogenic agent, and at least one adjuvant compound chosen from the acrylic or methacrylic polymers and the copolymers of maleic anhydride and alkenyl derivative.

2. Vaccine according to Claim 1, characterized in that it comprises, as adjuvant compound, a polymer of acrylic or methacrylic acid cross-linked with a polyalkenyl ether of a sugar or polyalcohol.

3. Vaccine according to Claim 2, characterized in that the polymer is cross-linked with an allyl sucrose or with allylpentaerythritol.

4. Vaccine according to Claim 1, characterized in that it comprises, as adjuvant compound, a copolymer of maleic anhydride and ethylene cross-linked, for example, with divinyl ether.

5. Vaccine according to any one of Claims 1 to 4, characterized in that the adjuvant compound is present in the vaccine in an amount of 0.01% to 2% w/v.

6. Vaccine according to Claim 5, characterized in that the concentration is 0.06 to 1% w/v, preferably 0.1 to 0.6% w/v.

7. Vaccine according to any one of Claims 1 to 6, characterized in that the naked DNA is a plasmid.

8. Vaccine according to any one of Claims 1 to 7, characterized in that it comprises a naked DNA incorporating and expressing a sequence of a pig, horse, dog, bovine, cat or avian pathogen.

9. Vaccine according to Claim 8, characterized in that it comprises at least one sequence of a pathogen chosen from:

- Aujeszky's disease virus
- porcine influenza virus
- porcine reproductive and respiratory syndrome virus
- porcine parvovirosis virus

- hog cholera virus
- Actinobacillus pleuropneumoniae
- equine rhinopneumonia virus
- equine influenza virus
- Cl. tetani
- Eastern encephalitis virus
- Western encephalitis virus
- Venezuelan encephalitis virus
- B. Burgdorferi
- Canine Distemper virus
- canine parvovirus
- canine coronavirus
- canine herpesvirus
- rabies virus
- bovine herpesvirus type 1 or 5
- bovine respiratory syncytial virus
- bovine pestivirus
- bovine parainfluenza virus type 3
- feline leukaemia virus
- feline panleukopaenia virus
- feline infectious peritonitis virus
- feline herpesvirus
- feline calicivirosis virus
- feline immunodeficiency virus
- Marek's disease virus
- Newcastle disease virus
- Gumboro disease virus
- avian infectious bronchitis virus
- avian infectious anaemia virus
- infectious laryngotracheitis virus
- avian leukosis virus
- avian pneumovirus
- avian influenza.

10. Use of a compound chosen from the polymers of acrylic or methacrylic acid and the copolymers of maleic anhydride and alkenyl derivative, as defined in any one of Claims 1 to 9, for acting as adjuvant for a DNA vaccine incorporating and expressing in vivo a heterologous nucleotide sequence.

MERIAL

ADJUVANT-CONTAINING DNA VACCINES

ABSTRACT OF THE TECHNICAL CONTENT OF THE INVENTION

The DNA vaccine comprises a naked DNA incorporating and expressing in vivo a nucleotide sequence encoding an antigenic polypeptide, preferably a gene of a pathogenic agent, and at least one adjuvant compound chosen from the acrylic or methacrylic polymers and the copolymers of maleic anhydride and alkenyl derivative. The adjuvant compound is preferably a carbomer or an EMA®.